CONODONT BIOSTRATIGRAPHY AND COMPARISON WITH GRAPTOLITE ZONES IN THE UPPER KOPE FORMATION IN NORTH CENTRAL KENTUCKY

SENIOR THESIS

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of the Requirements for the Degree,
Bachelor of Science

By

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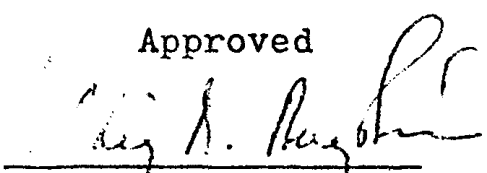
Approved



Faculty Adviser

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ABSTRACT

The zonal ranges of some key graptolites and conodonts have remained unclear in the Cincinnati region. This has caused uncertainty regarding the position of the Maysvillian Stage base as it travels through lithic units in this area. This study has more closely determined the Amorphognathus superbus - Amorphognathus ordovicicus zonal boundary and studied its relationship to the Climacograptus spiniferus - Climacograptus pygmaeus zonal boundary. The data has revealed that, in the Cincinnati region, these two zonal boundaries lie in closer stratigraphic proximity than previously thought. Both of these boundaries were found to be early Maysvillian in age. Also, it was determined that the Maysvillian Stage base lies in the C. spiniferus - C. pygmaeus transitional zone.

INTRODUCTION

There has been much speculation about conodont and graptolite zones and their use in determining the series and stage boundaries in the Upper Ordovician of the Cincinnati region. The lack of precise locality data and stratigraphic range data for some key graptolites in this region had hindered the determination of zonal boundaries for these fossils (Mitchell & Bergström, 1977). Also, the precise ranges of zonal conodonts of the genus Amorphognathus have remained unclear. Thus, their usefulness for determining specific stage and series boundaries in the Cincinnati region has been affected. This has caused various authors to present conflicting ideas about the location of these boundaries, especially outside the Cincinnati region.

The tristate area of Kentucky, Indiana, and Ohio is especially important since the Cincinnatian Series in this area, which consists of the Edenian, Maysvillian, and Richmondian Stages, is the American Upper Ordovician Standard (Pojeta, 1979). It is also an important area for the study of Middle and Upper Ordovician faunas of North America.

This study is concerned with the position of the Amorphognathus superbus - Amorphognathus ordovicicus zonal boundary and its relation to the Climacograptus spiniferus - Climacograptus pygmaeus zonal boundary in the Cincinnati region. These zonal boundaries are being studied in order to more clearly correlate the Maysvillian Stage on the basis of key index fossils. Sweet (1979) stated that "the base of

the Maysvillian Stage is fixed by tradition at the base of the Fairview Formation in the city of Cincinnati." As you travel southeastward from Cincinnati, however, the base of the Fairview Formation becomes younger in age when compared with biostratigraphic boundaries (Sweet & Bergström, 1970; Pojeta, 1979). This is why precise correlation of stage boundaries on the basis of fossils is important. It establishes a stage boundary which is not time transgressive through lithic units which may vary in age (fig. 1).

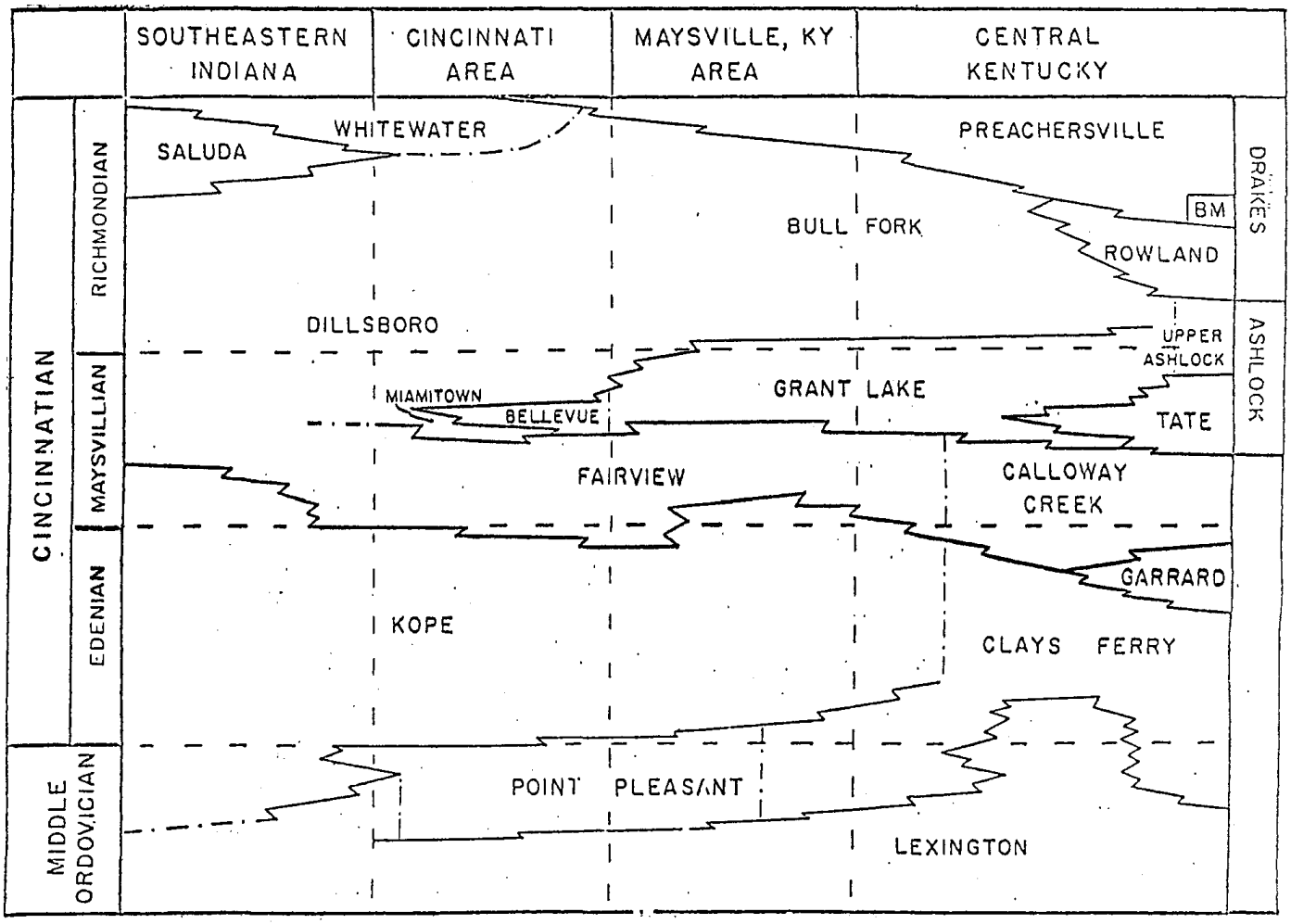
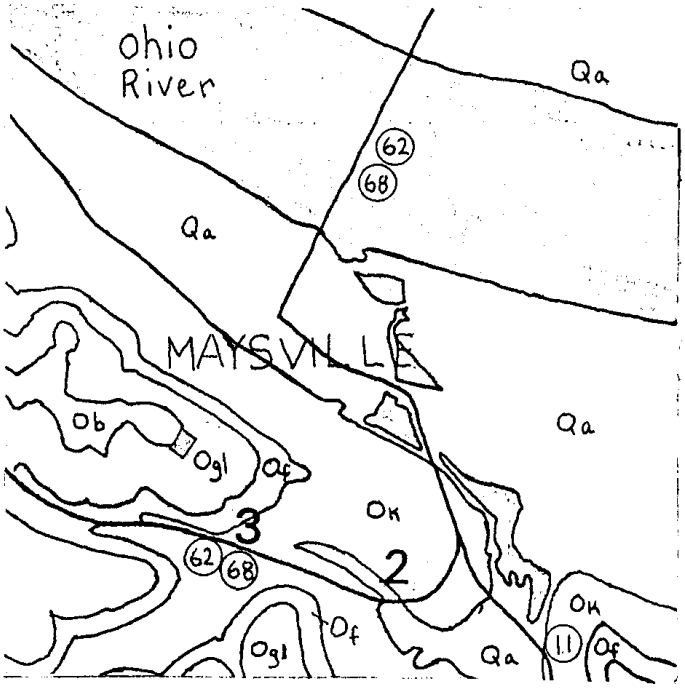


Figure 1. Generalized cross section from southeastern Indiana to central Kentucky which shows the relationship between formational boundaries and time boundaries.

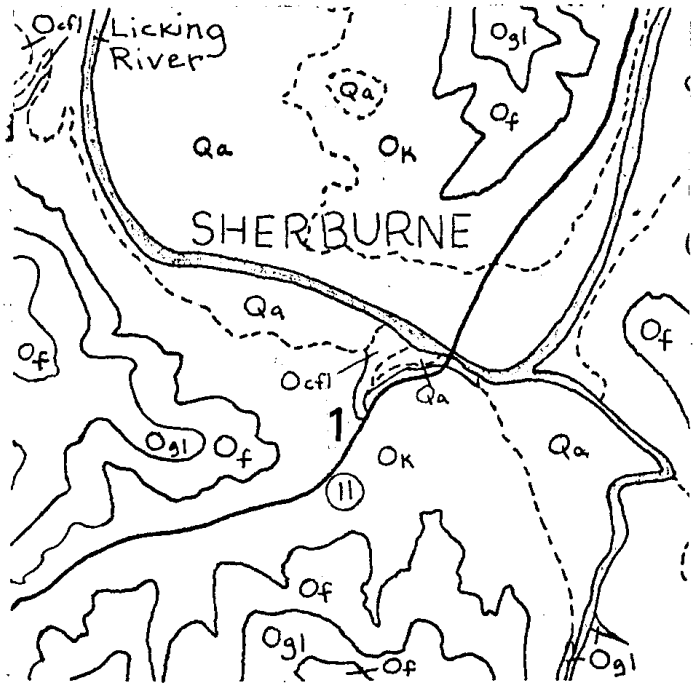


A) Portion of the Geologic Map of the Maysville West Quadrangle, Kentucky - Ohio.

EXPLANATION

Quaternary	Q_a	Alluvium
Ordovician	O_b	Bull Fork Formation
	O_{gl}	Grant Lake Limestone
	O_f	Fairview Formation
	O_k	Kope Formation
	O_{cfl}	Clay Ferry Formation
		Water
		Road
	11	Road sign
		Contact; Dotted where concealed

Scale 1:24,000



B) Portion of the Geologic Map of the Sherburne Quadrangle, northeastern Kentucky.

Figure 2.

STUDY AREA

A primary goal of this study was to find the Amorphognathus superbus - Amorphognathus ordovicicus zonal boundary. Since this boundary is thought to lie in the upper Kope Formation, rocks were collected from the upper Kope and lower Fairview Formations. Eighteen samples from three localities were collected and processed from these two formations. Samples were primarily collected from the limestone beds. All of the rocks lie within the classification scheme of Weiss and Norman (1960).

The Kope Formation has been estimated to be 73.5 meters thick by Weiss and Sweet (1964). The rocks range from 75 - 90% shale with interbedded limestone (Pojeta, 1979). They are highly fossiliferous (Weiss & Sweet, 1964). Water depth in the depositional environment is thought to have been less than 25 meters (Cressman, 1973; Pojeta, 1979) (fig. 6). The top of the formation is 211.3 meters above sea level at Maysville (Carpenter & Ory, 1961).

The Fairview Formation ranges in thickness from 70 - 110 feet (Pojeta, 1979). The rocks consist of 50 - 60% limestone interbedded with 35 - 40% shale and 5 - 15% limy siltstone (Peck, 1966; Ford, 1967; Pojeta, 1979). The Fairview Formation may have been deposited in deeper water than the Kope Formation (Osborne, 1973; Pojeta, 1979) although biogenic limestones were deposited on shallow shoal banks in southwestern Ohio and central Kentucky (Ford, 1968; Pojeta, 1979).

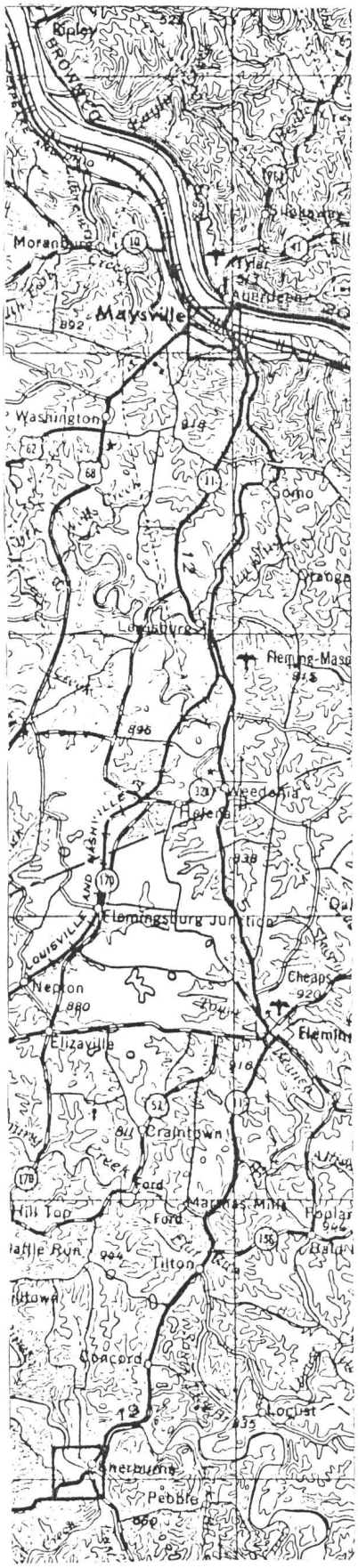
Locality 1: Road exposure on state route 11 near

the village of Sherburne in Bath County, Kentucky (fig. 3C). Roadcut lies on the west side of the road just south of the Licking River bridge. Locality 1 lies approximately 40 kilometers south of locality 2. It can be found in the Sherburne, Kentucky 7½' Quadrangle. At locality 1, the uppermost beds of the Kope Formation and the lowermost beds of the Fairview Formation are exposed.

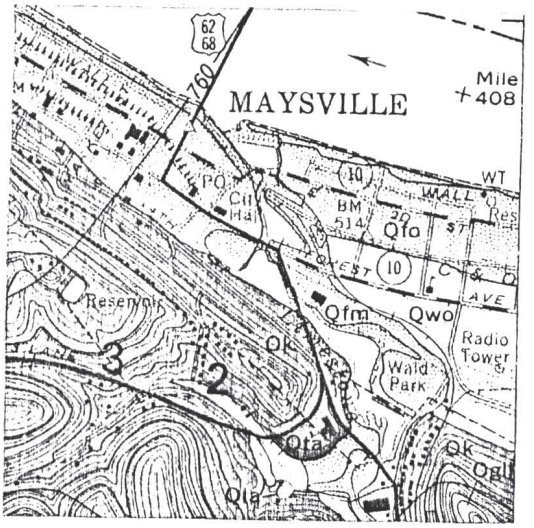
Locality 2: Exposure is located behind the Pepsi plant on U. S. route 62 in Maysville, Mason County, Kentucky (fig. 3B). It lies in the southeast ¼ of the Maysville West 7½' Quadrangle. The uppermost beds exposed at this site are approximately 15.3 meters below the top of the Kope Formation.

Locality 3: Exposure on the west side of the Styleline Furniture Store on U. S. route 62 in Maysville, Mason County, Kentucky (fig. 3B). Locality 3 lies 390 meters west of locality 2. It can also be found in the southeast ¼ of the Maysville West 7½' Quadrangle. The base of this exposure is approximately 10 meters below the top of the Kope Formation.

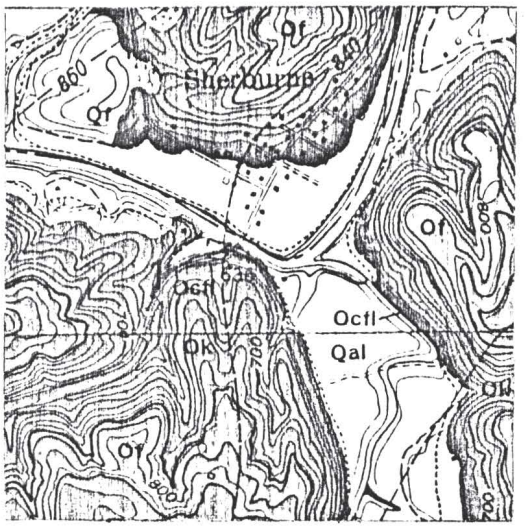
LOCALITIES



A) Regional map of study areas. Scale 1:250,000.



B) Portion of Maysville West, Ohio-Kentucky 7½' Quadrangle showing localities 2 & 3. Scale 1:24,000.



C) Portion of Sherburne, Kentucky 7½' Quadrangle showing locality 1. Scale 1:24,000.

Figure 3.

Figure 4.

Locality 2. Cut behind the Pepsi Cola warehouse at Maysville, Kentucky. Sample 82KD2-1 contained 10 elements of Holodontus superbus, the diagnostic element of Amorphognathus superbus. This sample is indicated by the arrow. Wolfgang Kurapkat (1.83 meters) for scale.

Figure 5.

Locality 3. Cut west of the Styleline Furniture Factory at Maysville, Kentucky. 8 elements of Amorphognathus sp. were found in this section.

STUDY PROCEDURES

Eighteen rock samples were collected from three localities in north central Kentucky. To extract the conodonts from the rocks, the samples were crushed and one kilogram of each sample was dissolved in seven hundred grams of 10% acetic acid. Sample residues were washed through 20-mesh and 150-mesh standard sieves. This removed clay, undissolved carbonate material, and large particles from the insoluble fraction containing conodonts. Sample residue remaining on the 150-mesh screen was then dried. The dry residue was run through the isodynamic magnetic separator. This separated the magnetic and paramagnetic particles from the sample residue to be searched and increased concentration of the conodont elements. Large amounts of residue were separated by using tetrabromoethane. The conodonts and other particles with a specific gravity heavier than the liquid sank to the bottom while all other particles rose to the top of the liquid. The heavy fraction was removed and washed with acetone to remove the tetrabromoethane. This further concentrated the conodonts in the sample residue. The conodont elements were then picked from the remaining insoluble sample residue under a binocular microscope with a wet 10/0 sable brush. They were placed on standard micropaleontological slides labeled with the sample number.

The conodont elements were moderately well preserved. All elements were amber and translucent indicating that they were unaltered by temperature and time.

CONODONT BIOSTRATIGRAPHY

All of the specimens studied herein were derived from rocks collected from the upper Kope and lower Fairview Formations (fig. 2). Localities 1 and 3 included both formations while locality 2 included only the upper Kope Formation.

The Kope Formation is primarily Edenian in age (early Late Ordovician), but its upper portion in the Maysville area is of early Maysvillian age (middle Late Ordovician) (Pojeta, 1979). The upper Kope Formation at Maysville, Kentucky has been correlated with the lower Fairview Formation at Cincinnati, Ohio by Carpenter and Ory (1961) (fig. 1). The Fairview Formation is Maysvillian (middle Upper Ordovician) in age (Sweet, 1979).

Samples from both of the Maysville localities (2 & 3) produced abundant conodonts while the Sherburne locality (1) contained few conodonts. Four of the Sherburne samples were barren (Table 2).

There are two faunal types represented by the species found, the North American Midcontinent Province and the North Atlantic Province. Amorphognathus is the only species of the North Atlantic Province represented in the Maysville area (Sweet, 1979). Species of Amorphognathus are used as zone fossils in the North Atlantic conodont zone succession. Of interest here are the two species that are used to define the Amorphognathus superbus - Amorphognathus ordovicicus zonal boundary.

The most diagnostic feature which separates Amorphognathus superbus from Amorphognathus ordovicicus is the holodontiform element. The holodontiform element of A. ordovicicus has never been found in the Cincinnati region (Sweet, 1979). This has been the primary block to establishing the A. superbus - Amorphognathus ordovicicus zonal boundary. Since A. superbus is an important index fossil and both A. superbus and A. ordovicicus are known worldwide, this zonal boundary is important to establish time-biostratigraphic relationships in the Cincinnati region and elsewhere in the world.

Locality 1: Six samples from this locality were processed by the author. Four of these samples were barren while two of the samples contained moderate amounts of conodonts. All of the species are referable to the North American Midcontinent Province. Locality 1 is equivalent to Evans' (1981) locality E.

No elements of the genus Amorphognathus were found at this locality. Therefore, no information about the position of the A. superbus - A. ordovicicus zonal boundary could be gathered from this locality.

The presence of Drepanodus suberectus and Phragmodus undatus seems to indicate a more offshore, deeper water environment in this area. The absence of Rhipidognathus and Icriodella in these rocks may also be an indication of deeper water.

Outerbridge (1970) mapped the top of the Kope Formation at this locality at 242 meters. The six samples processed from this locality included rocks in the uppermost Kope

Formation and rocks from near this boundary and the lowermost Fairview Formation.

Locality 2: Six samples were collected and processed from this locality by the author. All of the samples contained conodonts in moderate to abundant amounts. Representatives of both the North American Midcontinent and the North Atlantic Provinces are present. Locality 2 is equivalent to Evans' (1981) locality B.

The most significant results were derived from this locality. Specimens of the genus Amorphognathus were found in each sample. A. superbus was identified 1.8 meters above the base of the section or 190.8 meters above sea level in sample 82KD2-1 (fig. 7). In the past, the name Holodontus superbus was applied to holodontiform elements of A. superbus. The name Tetraprioniodus delicatus was applied to ramiform elements of A. superbus. These names are used in Table 2. No holodontiform elements were found in my samples from younger rocks. Therefore, all other elements of the apparatus above this point were referred to as Amorphognathus sp. The A. superbus - A. ordovicicus zonal boundary could not be more closely determined since no holodontiform elements of A. ordovicicus could be found. It must lie, however, above the 190.8 meter level, but probably rather near it because the holodontiform elements are somewhat transitional to those of A. ordovicicus.

Locality 2 contained the most varied fauna of all the three localities. The species represented in this section

were faunas which flourished in a deeper water, offshore environment. Amorphognathus was thought by Seddon and Sweet (1971) to inhabit a depth deep beneath the water surface in the North American Midcontinent Province.

The top of the outcrop in the section lies at approximately 196 meters above sea level (Evans, 1981). The exposed sequence is 7 meters thick (Evans, 1981). The uppermost beds are approximately 15.3 meters below the top of the Kope Formation. The Maysvillian Stage base is approximately 65 feet (19.8 meters) below the top of the Kope Formation in the Maysville section (fig. 8) (Sweet, pers. comm., 1982).

Locality 3: Six samples were collected and processed from this locality by the author. All of the samples contained conodonts. Species representing both the North American Midcontinent and North Atlantic Provinces were found. Locality 3 is equivalent to Evans' (1981) locality D.

Two of the samples (82KD3-2 & 82KD3-4) contained elements of the genus Amorphognathus. No holodontiform elements were found so the apparatus was identified as Amorphognathus sp. Since no holodontiform elements were present, no information about the zonal boundary could be derived. It can only be stated that either A. superbus or A. ordovicicus is present at this level.

The species present at locality 3 are the same as those pesent at locality 1 with the addition of Amorphognathus sp. and Belodina compressa. This indicates a deep water, offshore environment.

Carpenter and Ory (1961) determined the top of the Kope Formation at this site to be at an elevation of 211.3 meters (682 feet) (fig. 8). The base of the outcrop is approximately 10 meters below the top of the Kope Formation (Evans, 1981). The base of the outcrop is at approximately 201 meters.

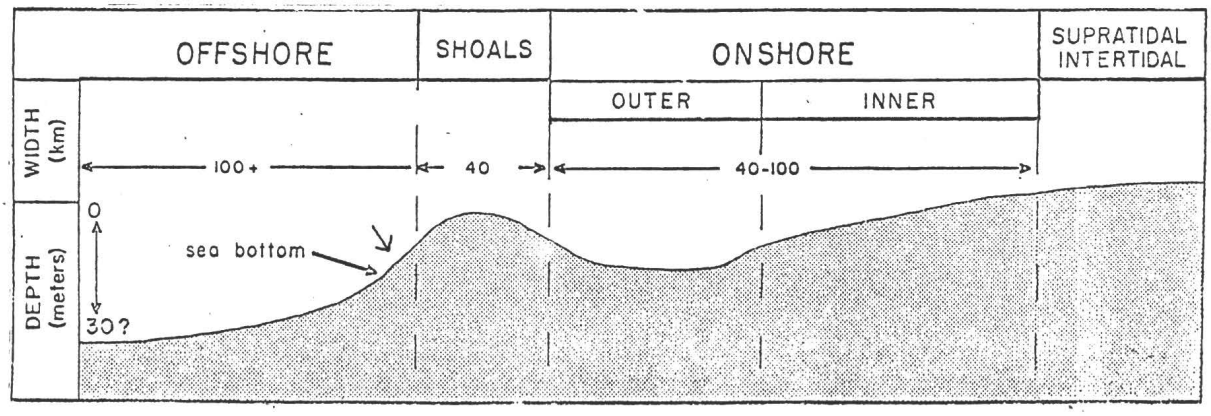
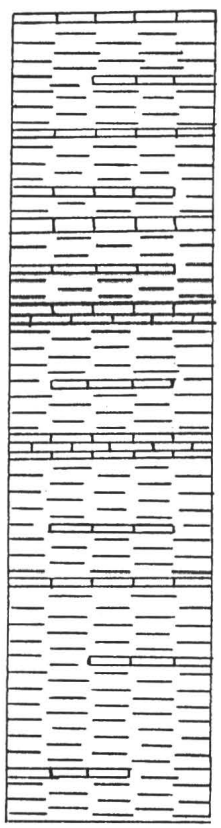


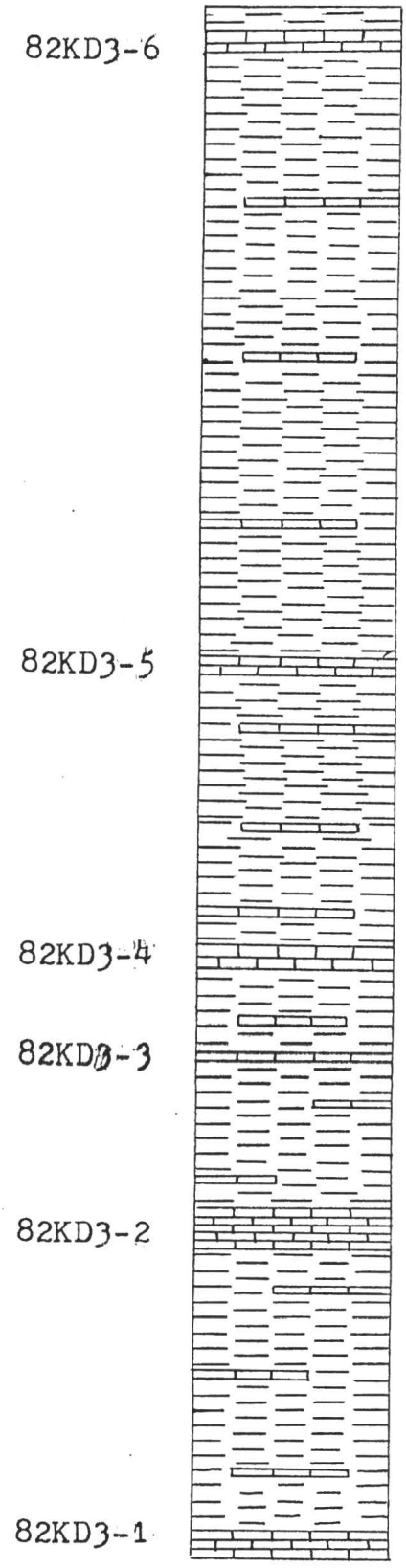
Figure 6. Proposed interpretation of the paleoenvironment of locality 2 indicated by the arrow.

Figure 7, Stratigraphic cross section of localities 2 & 3 showing sample locations. Scale 1:60.

Bar = 1 meter



Locality 2



Locality 3

COMPARISON OF CONODONT AND GRAPTOLITE ZONES

In the past, correlation of the Maysvillian Stage has been difficult due to a lack of conodont and graptolite data in the Cincinnati region. Indeed, Mitchell and Bergström (1977) state that "... finds of graptolites other than Climacograptus typicalis are rare in the Upper Ordovician rocks of the Cincinnati region. The correlation between Cincinnati Stages and standard graptolite zones has been based on very little direct graptolite evidence and mostly of fossils other than graptolites." Also, the Amorphognathus superbus - Amorphognathus ordovicicus zonal boundary has never been accurately determined in the Cincinnati region, though advanced forms of A. superbus have been found in the Lower Maysvillian Stage (Sweet, 1979).

This problem has been alleviated to some degree by the study of Evans (1981) and my own new data. These studies, in which the Climacograptus spiniferus - Climacograptus pygmaeus and Amorphognathus superbus - Amorphognathus ordovicicus zonal boundaries were more clearly determined, have allowed for a more accurate correlation than has been previously reported.

A primary objective of Evans' research was to determine the stratigraphic position and range of C. pygmaeus. The appearance of this species marks the base of the C. pygmaeus Zone. In his study, he more closely defines the C. spiniferus - C. pygmaeus zonal boundary in the Cincinnati region and tentatively places this boundary between 189 - 192 meters

at his locality B. Evans bases his boundary determination on a transitional population of C. typicalis - C. pygmaeus which he collected at the base of the section. He identified C. pygmaeus in the upper 2.5 meters of the 7 meter section (fig. 8). This would place the C. spiniferus - C. pygmaeus zonal boundary in the upper Kope Formation in rocks of early Maysvillian age.

The A. superbus - A. ordovicicus zonal boundary is thought to lie in the upper Kope Formation (Bergström, pers. comm., 1982). Evidence obtained by the author indicates that the A. superbus Zone ranges into the upper Kope Formation. A. superbus was identified at 190.8 meters above sea level or 1.8 meters above the base of the section at locality 2 (fig. 8). The A. superbus - A. ordovicicus zonal boundary could not be definitely established, but it appears to lie either in the upper Kope Formation or the lower Fairview Formation. This would place the zonal boundary in the early Maysvillian Stage.

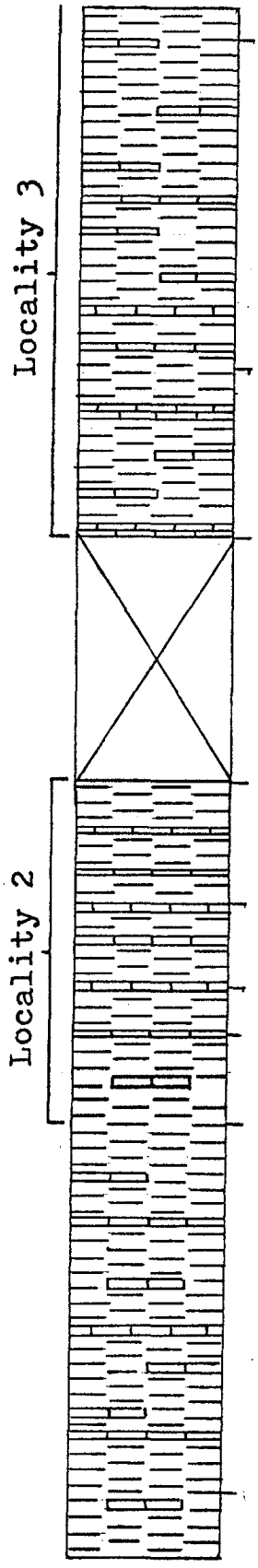
Bergström (1976) found that in Texas the A. superbus - A. ordovicicus zonal boundary is in strata no younger than the C. spiniferus Zone. The A. superbus - A. ordovicicus zonal boundary in New York has been found to lie high in the C. spiniferus Zone (Bergström, 1971b). Mitchell and Bergström (1977) have speculated that the C. spiniferus - C. pygmaeus zonal boundary lies in the middle of the Maysvillian Stage since the A. superbus - A. ordovicicus zonal boundary is thought to lie in the lower Maysvillian Stage. Evidence

compiled by Evans (1981) and the author indicates that both the C. spiniferus - C. pygmaeus and the A. superbus - A. ordovicicus zonal boundaries lie in the early Maysvillian Stage. It is even more interesting to note that the A. superbus - A. ordovicicus zonal boundary may lie with, or even more likely, above the C. spiniferus - C. pygmaeus zonal boundary in the Cincinnati region. This is indicated by the fact that, at locality 2, A. superbus has been identified at approximately 190.8 meters and C. pygmaeus has been identified at approximately 193.5 meters above sea level. A. superbus has also been identified within the 189 - 192 meter range of the C. typicalis - C. pygmaeus transitional population described by Evans.

These boundary determinations conflict with the findings of Bergström and Mitchell (1977) in New York and Texas and places these two zonal boundaries in much closer proximity than has been previously determined in these areas. It also places the C. spiniferus - C. pygmaeus zonal boundary at an earlier stage level than in New York and Texas.

The Maysvillian Stage base as determined by Sweet (pers. comm., 1981) lies within the C. spiniferus - C. pygmaeus transitional population range in locality 2 (fig. 8). It also appears to lie in the A. superbus Zone. This information can be used to more clearly define the Maysvillian Stage base.

Figure 8. Stratigraphic comparison of conodont and graptolite zones and their relation to the Maysvillian Stage base. Scale 1:160



212.0 m.
211.3 m Top of Kope Formation

Bar = 1 meter

204.5 m Top of C. pygmaeus range

201.0 m Base of locality 3

196.0 m Top of locality 2

193.5 m C. pygmaeus near top of transitional zone

191.8 m Maysvillian Stage base

190.8 m H. superbus identified (advanced A. superbus

189.0 m Base of locality 2

181.3 m C. typicalus identified (Evans' locality A)

180.0

CONCLUSIONS

During the course of research for this paper, some interesting new data was discovered. Even though the A. superbus - A. ordovicicus zonal boundary could not be definitely established, it has been more closely pinpointed in the upper Kope Formation. The A. superbus - A. ordovicicus and C. spiniferus - C. pygmaeus zonal boundaries were found to lie closer together than in other areas where they have been studied. The A. superbus - A. ordovicicus zonal boundary may even lie above the C. spiniferus - C. pygmaeus zonal boundary which is opposite to what has been found in other regions. The C. spiniferus - C. pygmaeus zonal boundary was determined to be early Maysvillian in age in the Cincinnati region. This conflicted with research from other areas in which it was thought to be middle Maysvillian in age. Interestingly enough, the Maysvillian Stage base fell within the C. spiniferus - C. pygmaeus transitional population range. This is important in the correlation of the Maysvillian Stage boundary on the basis of key index fossils in order to establish a stage boundary which is not time transgressive. The fact that this region is the American Upper Ordovician Standard increases the significance of establishing this boundary on universally acceptable criteria.

TABLE 1: Total list of species present in the samples studied

Plectodina furcata (Hinde)
Phragmodus undatus Branson and Mehl
Ozarkodina tenuis Branson and Mehl
Oulodus oregonia (Branson, Mehl, and Branson)
Drepanodus suberectus (Branson and Mehl)
Belodina compressa (Branson and Mehl, 1933)
Panderodus gracilis
Oistodus venustus Stauffer
Amorphognathus superbus (Rhodes, 1953)
Amorphognathus sp.
Holodontus superbus Rhodes
Tetraprioniodus delicatus
Staufferella falcata 1979

TABLE 2: Conodont elements present in samples were collected from the upper Kope and lower Fairview Formations. For sample location and elevation, see Table 3. Vertical totals indicate the total number of conodont elements in each sample. Horizontal totals indicate the total number of each species. The name Holodontus superbus is used to refer to the holodontiform element of Amorphognathus superbus. The name Tetraprioniodus delicatus is used to refer to the ramiform element of Amorphognathus superbus.

SYMBOLS:

The sample was partially picked.

* The sample was barren.

- The sample contained none of that species.

	1-1	1-2	1-3	1-4	1-5	1-6	2-1 #	2-2	2-3	2-4	2-5	2-6	3-1	3-2	3-3	3-4	3-5	3-6	TOTAL
Plectodina furcata	*	*	8	*	26	*	71	5	5	7	16	120	15	126	1	21	38	157	616
Phragmodus undatus	*	*	8	*	40	*	145	40	19	53	97	215	9	35	-	3	30	83	782
Ozarkodina tenuis	*	*	1	*	18	*	1	12	7	11	19	7	3	19	-	6	8	18	130
Oulodus oregonia	*	*	2	*	36	*	28	18	15	7	8	-	32	15	-	14	41	40	256
Drepanodus suberectus	*	*	2	*	9	*	-	-	2	3	3	5	3	13	-	5	3	3	51
Belodina compressa	*	*	-	*	-	*	-	-	-	1	1	3	-	4	-	-	-	-	9
Panderodus gracilis	*	*	-	*	-	*	-	-	-	-	-	3	-	-	-	-	-	-	3
Oistodus venustus	*	*	-	*	-	*	-	-	-	-	-	5	-	-	-	-	-	-	5
Staufferella falcata	*	*	-	*	-	*	-	-	-	-	-	-	1	-	-	-	-	1	2
Amorphognathus superbus	*	*	-	*	-	*	10	-	-	-	-	-	-	-	-	-	-	-	10
Amorphognathus sp.	*	*	-	*	-	*	-	8	6	11	18	-	-	7	-	1	-	-	51
Holodontus superbus	*	*	-	*	-	*	10	-	-	-	-	-	-	-	-	-	-	-	10
Tetraprioniodus delicatus	*	*	-	*	-	*	236	-	-	-	3	6	-	-	-	-	-	-	245
TOTAL	0	0	21	0	129	0	501	83	54	93	165	364	63	219	1	50	120	302	

TABLE 3: Location and elevation of each sample.

	Meters Above Base of Section	Meters Above Sea Level
Locality 1		
82KD1-1	12.67	243.3
82KD1-2	14.20	244.8
82KD1-3	14.33	244.9
82KD1-4	16.15	246.8
82KD1-5	17.07	247.7
82KD1-6	18.85	249.5
Locality 2		
82KD2-1	1.78	190.8
82KD2-2	2.74	191.7
82KD2-3	3.73	192.7
82KD2-4	4.39	193.4
82KD2-5	5.11	194.1
82KD2-6	5.99	195.0
Locality 3		
82KD3-1	.23	202.6
82KD3-2	2.41	204.8
82KD3-3	3.89	206.3
82KD3-4	4.57	207.0
82KD3-5	6.86	209.3
82KD3-6	11.73	214.1

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Explanation of Plate 1

Amorphognathus superbus (Rhodes, 1953)
1) Amorphognathiform element, upper view, X 210
2) Ramiform (ligonodiniform) element, lateral view, X 200
3) Ramiform (tetraprioniodiform) element, lateral view, X 200
4) Ramiform (tetraprioniodiform) element, lateral view, X 260
5) Holodontiform element, lateral view, X 280
6) Holodontiform element, lateral view, X

Belodina compressa (Branson and Mehl, 1933)
7) Grandiform element, lateral view, X 100

Drepanodus suberectus (Branson and Mehl)
8) Drepanodiform element, lateral view, X 80

Oistodus venustus Stauffer
9) Oistodiform element, lateral view, X 260

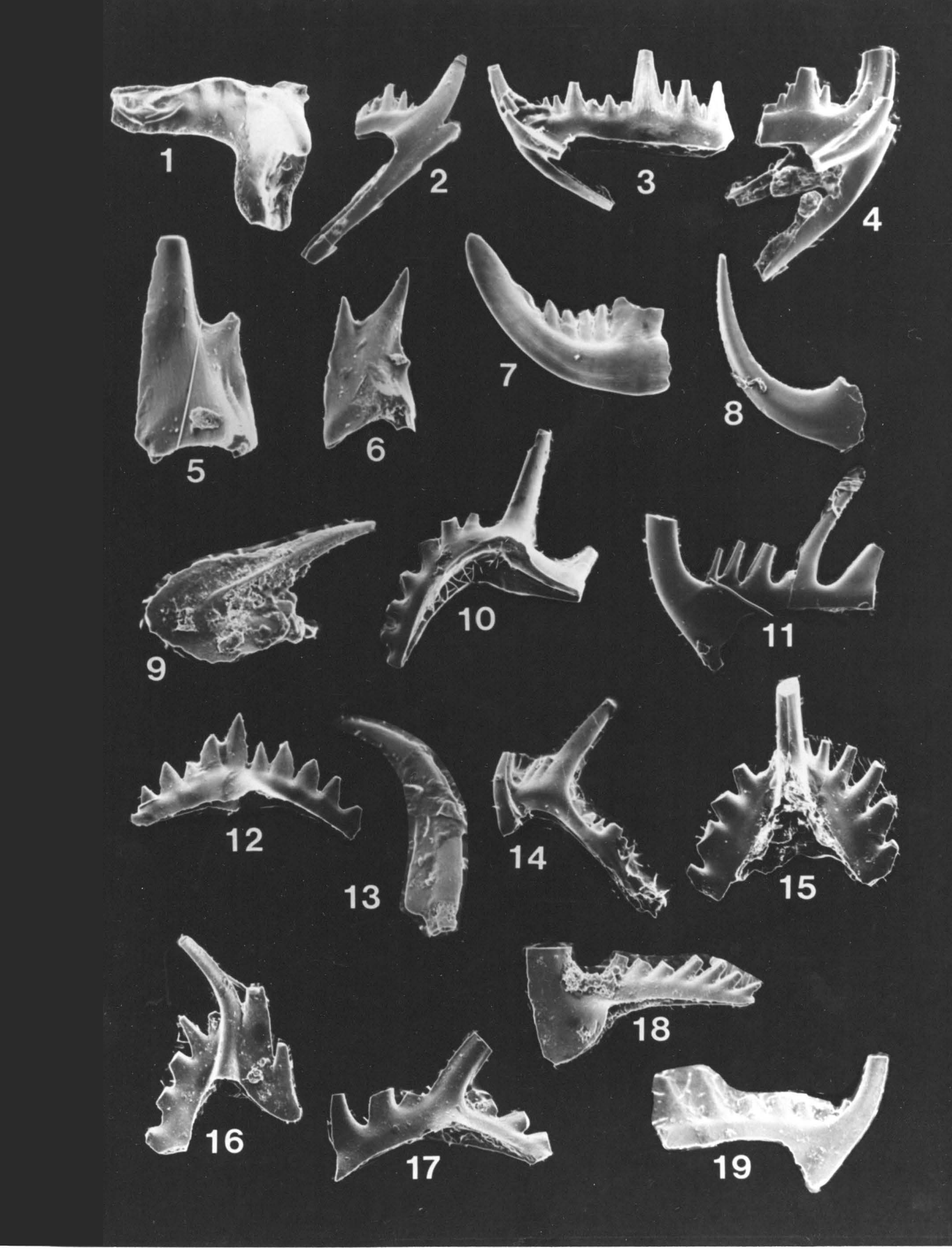
Oulodus oregonia (Branson, Mehl, and Branson)
10) Oulodiform element, lateral view, X 100
11) Cordylodiform element, lateral view, X 110

Ozarkodina tenuis Branson and Mehl
12) Lateral view, X 110

Panderodus gracilis
13) Lateral view, X 200

Phragmodus undatus Branson and Mehl
14) Dichognathiform element, lateral view, X 110

Plectodina furcata (Hinde)
15) Trichonodelliform element, upper view, X 240
16) Zygognathiform element, upper view, X 160
17) Prioniodelliform element, lateral view, X 225
18) Cyrtoniodiform element, lateral view, X 160
19) Cordylodiform element, lateral view, X 110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